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Linearly Tapered Slot Antenna Impedance Characteristics

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Space Administration

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INTRODUCTION

The linearly tapered slot antenna (LTSA) is a very useful antenna because of its simple construction, high gain and wide bandwidth (ref. 1). Previous experimental studies (refs. 2 and 3) emphasized the dependance of the beam width, directivity and gain on the flare length and angel of the LTSA. In addition we have previously demonstrated several novel techniques to feed a LTSA (ref. 4) and also studied the effect of a dielectric overlay on the LTSA beam width and gain (ref. 5). In all of the above investigations, the input impedance of the LTSA has been approximated to be the same as that of an equivalent biconical fin antenna (ref. 3). This approximation is valid only over a certain frequency band.

This paper demonstrates for the first time an accurate technique to determine the input impedance of a LTSA using a microwave wafer probe and a set of on-wafer Thru-Reflect-Line (TRL) slot line calibration standards. Experimental results are presented which show the variation of the input impedance as a function of the frequency with the semi-flare angle and flare length used as parameters.

EXPERIMENTAL METHODOLOGY

The LTSA is fabricated on a 0.01 in. thick RT/duroid 6010.5 ($\varepsilon_r = 10.5$). The layout of the LTSA is shown in figure 1. In this figure θ and L represent the semi-flare angle and flare length respectively. The LTSA is excited through a short length of a slot line by a ground-signal microwave probe (Picoprobe Inc.) as shown in figure 2. The slot line minimizes the interaction between LTSA input terminals and the parasitic associated with the probe tips.

The reflection coefficient of the LTSA is de-embedded from the measured reflection coefficient (S_{11}) at the input terminals of the slot line. The de-embedding is done with a HP 8510C Automatic Network Analyzer, a set of TRL on-wafer slot line calibration standards which is shown in figure 3 and the NIST de-embedding software (ref. 6). The software runs on a HP 9000 computer and controls the Network Analyzer.

RESULTS AND DISCUSSIONS

LTSA with Constant Length

The real and imaginary parts of the de-embedded LTSA input impedance $Re(Z_{in})$ and $Im(Z_{in})$ as a function of the frequency for $\theta = 5°$ and L = 1 in. are shown in figures 4(a) and (b) respectively. The plots of Z_{in} show a series of resonances over the frequency band. As the frequency varies from 2 to 26.5 GHz, the normalized length of the LTSA (L/λ_o) varies from 0.17 λ_o to 2.24 λ_o, where λ_o is the free space wavelength. The corresponding variation in the normalized width of the mouth of the LTSA (W/λ_o) is from 0.03 λ_o to 0.4 λ_o. In a LTSA at the lower end of the frequency band, W/λ_o is very small and hence the electric field intensity is large which results in a large wave impedance. The large wave impedance in turn results in a large $Re(Z_{in})$ for the first resonance mode, typically about 2500 Ω. On the other hand at the upper end of the frequency band, the effective aperture is large and hence $Re(Z_{in})$ is small, typically about 145 Ω. The minimum value of $Re(Z_{in})$ (occurs between the resonances at the high end of the frequency band) is about 40 Ω which is approximately half the value predicted in reference 2.

Measurements on several other LTSAs with the same L but with θ progressively increased from 5° up to 20° in steps of 2.5° show that at the lower end of the frequency band $Re(Z_{in})$ decreases as θ increases. These results also support the above discussion. Figures 5(a) and (b) show $Re(Z_{in})$ and $Im(Z_{in})$ respectively for θ = 20°. From figure 5(a), $Re(Z_{in})$ is about 650 and 145 Ω at the low and the high end of the frequency band respectively. The minimum value of $Re(Z_{in})$ is about 85 Ω which is about the same as predicted in reference 2.

LTSA with Constant Semi-Flare Angle

Figures 6(a) and (b) present the $Re(Z_{in})$ and $Im(Z_{in})$ respectively for θ = 10° and L = 3 in. In this case L/λ_0 is about three times larger than the previous case and consequently there are about three times more resonances. For this LTSA, the $Re(Z_{in})$ is initially large and is as high as 1300 Ω when $L/\lambda_0 = 1.15$. $Re(Z_{in})$ reduces as L/λ_0 increases and is in the range of 55 to 130 Ω for $L/\lambda_0 > 3.6$.

CONCLUSIONS

An experimental technique to de-embed the input impedance of a LTSA from the measured reflection coefficient has been presented. The results show that the input impedance is dependent on the semi-flare angle and the length of the LTSA. The $Re(Z_{in})$ is large, on the order of few thousand ohms, when the electrical length of the LTSA is small. However for an electrically large LTSA, $Re(Z_{in})$ is in the range of 55 to 130 Ω. These results have potential applications in the design of broad band impedance matching networks for LTSAs.

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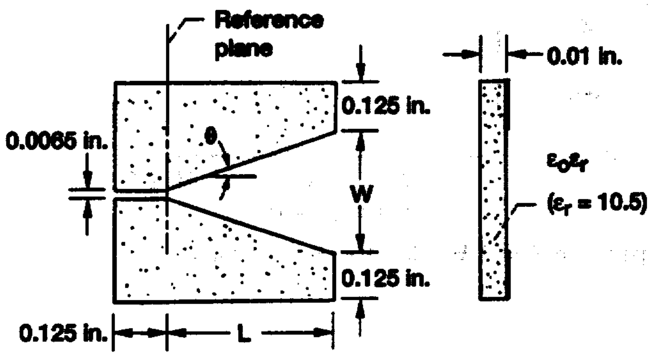

Figure 1.—Schematic of the LTSA.

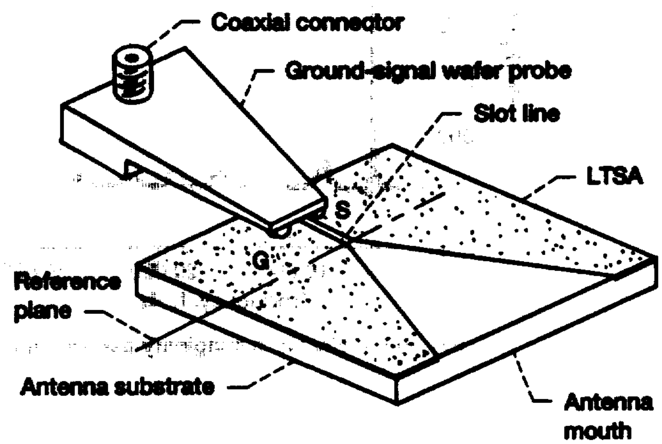

Figure 2.—Experimental set-up.

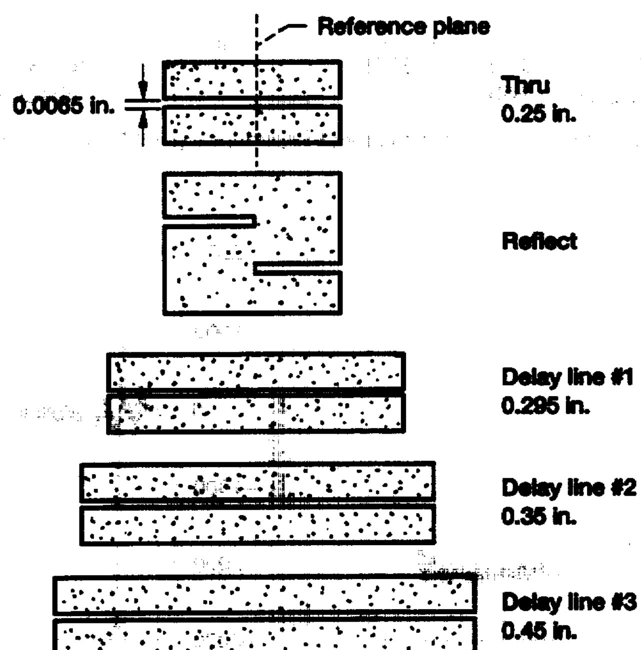

Figure 3.—TRL on-wafer slot line calibration standards.

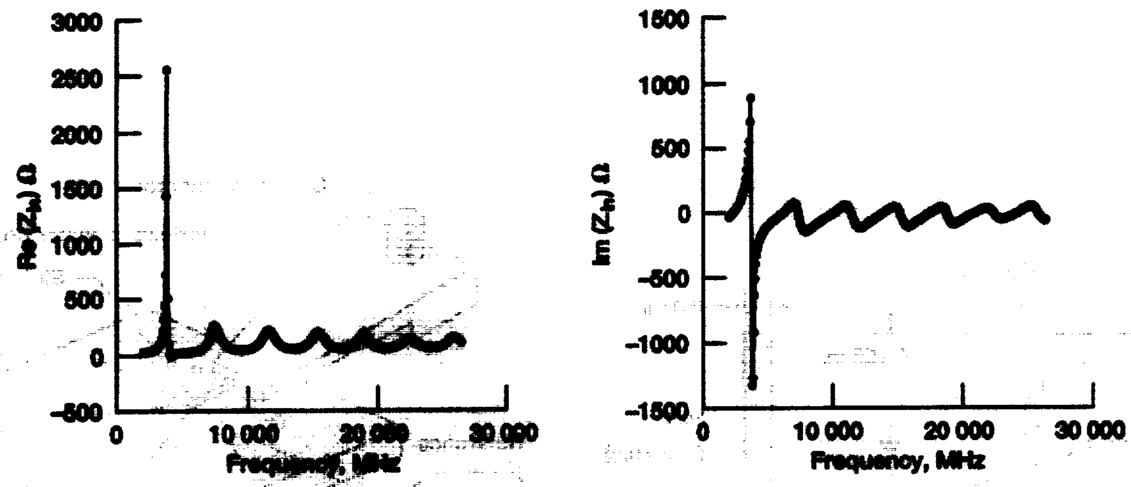

Figure 4.—Real and imaginary part of the input impedance (θ = 5°, W = 0.179 inch, L = 1 inch).

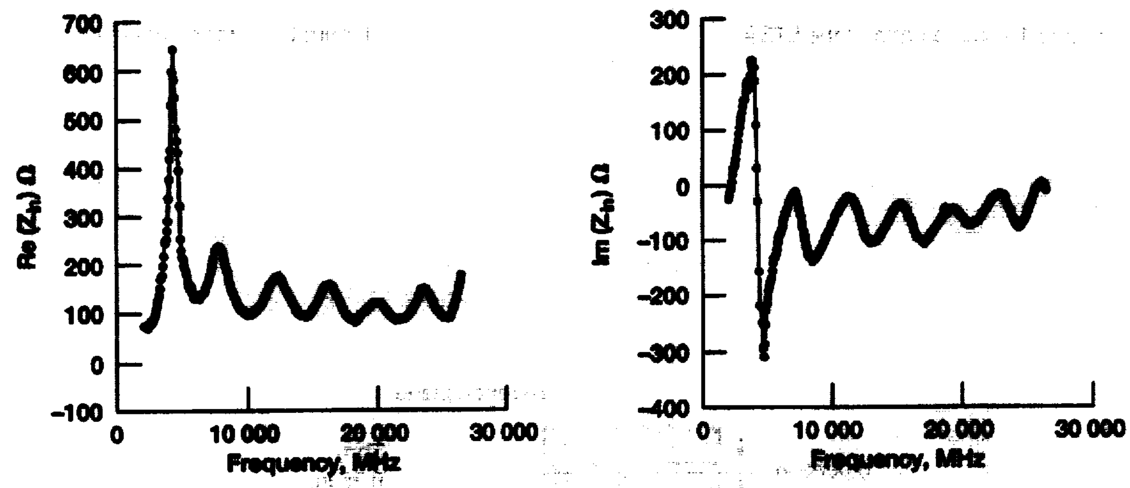

Figure 5.—Real and imaginary part of the input impedance (θ = 20°, W = 0.732 inch, L = 1 inch).

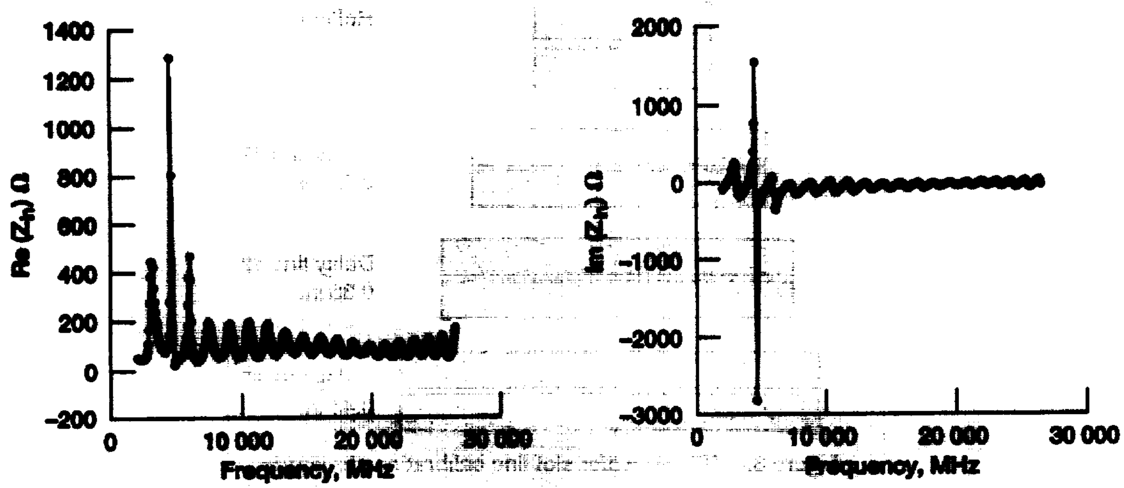

Figure 6.—Real and imaginary part of the input impedance (θ = 10°, W = 1.06 inch, L = 3 inch).

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13. ABSTRACT ***(Maximum 200 words)***

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